

SECTION 260000

ELECTRICAL

PART 1 – GENERAL

1.01 REFERENCE TO GENERAL CONDITIONS

- A. The General Conditions shall be considered as forming a part of the specifications and shall be carefully examined before proposals for any work are submitted. Unless the specifications contain statements which are not more definitive or more restrictive than those contained in the General Conditions, the specifications shall not be interpreted as waiving or overruling any requirements expressed in the General Conditions.
- B. The Electrical Contractor shall comply with the International Building Code, 2009 Edition “Seismic Restraints for Electrical Systems” and shall comply with all requirements of this section and any local or county requirements (where applicable).

1.02 SCOPE OF WORK

- A. The scope of work shall consist of all labor, materials, equipment, and services required to complete all work indicated on the drawings and in the specifications, for a complete project. The work shall include, but shall not be limited to, the following:
 - 1. Secondary distribution system including modifications: secondary conductors from utility company pad mounted transformer to service entrance rated Automatic Transfer Switch (ATS), feed to the main switchboard, over current and switching devices, feeders, cables, wiring, raceways, and all other components required for a complete distribution system.
 - 2. All lighting systems (indoor and outdoor, normal, emergency and exit) including all fixtures, lamps, mounting accessories, switches, outlet, wiring, raceways and all other components and fittings required for a complete lighting system.
 - 3. Lighting control system including: Time switches, photocells, lighting contactors, auxiliary relays, wiring, raceways and all other devices required.
 - 4. Grounding and bonding of all electrical systems and equipment.
 - 5. Wiring devices (switches and receptacles) complete with associated wall plates.

6. Power wiring to all miscellaneous equipment.
7. Testing of all electrical systems.
8. Equipment supports and fastenings.
9. Branch circuit wiring including all boxes, fittings and devices.
10. Temporary building power by a portable generator as may be required for utility shut downs during the construction period.
11. Seismic restraints for electrical systems
12. Backcharges for electric service outages and metering changes performed by the utility company.
13. Excavation and backfill for underground conduit banks shall be provided by the Electrical Contractor.
14. Concrete and masonry work, including generator pad, filling of existing ventilation louver openings, etc. shall be provided by the Electrical Contractor.
15. All other systems hereinafter specified or indicated on the Contract Drawings, complete, leaving ready and electrical system in perfect operating condition.
16. The foregoing is intended merely as a general description of the electrical systems and requirements and does not outline the work required by these Specifications and Contract Drawings. Moreover, the Specifications and Contract Drawings require the furnishing and installing of certain equipment and apparatus and the performance of certain work which forms no part of the aforementioned systems and requirements.

1.03 RELATED WORK IN OTHER SECTIONS

- A. The following equipment items and work shall be the responsibility of others:
 1. All work associated with this project will be the responsibility of the electrical contractor

1.04 CODES, PERMITS AND INSPECTIONS

- A. All work shall meet or exceed the latest requirements of all national, state, county, municipal and other authorities exercising jurisdiction over the general and electrical construction work of this project.

- B. All required permits, fees and inspection certificates shall be obtained, paid for, and made available at the completion of the work. The Electrical Contractor shall give all required notices, pay all governmental taxes, and obtain all approvals as necessary to complete the project.
- C. All electrical work shall be governed by the National Electric Code and other applicable sections of the National Fire Code, as published by the National Fire Protection Association, 60 Batterymarch Park, Quincy, Massachusetts 02269.
- D. Installation procedures, methods and conditions shall comply with the latest requirements of the Federal Occupational Safety and Health Administration (OSHA) and the Americans with Disabilities Act (ADA).

1.05 GUARANTEES AND CERTIFICATIONS

- A. All work shall be guaranteed to be free from defects. Any defective materials or workmanship, as well as damage to the work of all trades resulting from same, shall be replaced or repaired as directed for the duration of the stipulated guarantee periods.
- B. The duration of the guarantee period shall be one year following the date of acceptance of the work. The generator shall be guaranteed for 5 years.
- C. The date of acceptance shall be the date of the final payment for the work or the date of a formal notice of acceptance, whichever is earlier.
- D. Non-durable items, such as electric lamps, shall be replaced up to the date of acceptance by the Electrical Contractor.
- E. If during that period of general guaranty, any part of the work fails, becomes unsatisfactory, or does not function properly due to any fault in material or workmanship, whether or not manufactured or job built, the Electrical Contractor shall upon notice from the Owner promptly proceed to repair or replace such faulty material or workmanship without expense to the Owner including repair or restoration of any damaged sections of the premises resulting from such faults.
- F. In the event that a repetition of any one defect occurs indicating a probability of further failure and which can be traced to faulty design, material, or workmanship, then repair or replacement shall not continue to be made but the fault shall be remedied by a complete replacement of the entire defective unit.

1.06 SHOP DRAWINGS AND OTHER INFORMATION REQUIRED

- A. Prior to purchasing any equipment or materials, a list of their manufacturers shall be submitted to the owner for approval.

- B. Prior to assembling or installing the work, (6) copies of shop drawings for each item or system listed under section 1.02 (Scope of Work) shall be submitted for approval.
- C. Documents will not be accepted for approval unless:
 - 1. They comply with the requirements of the General Conditions.
 - 2. One original brochure and six (6) copies of each are submitted.
 - 3. They include complete information pertaining to appurtenances and accessories.
 - 4. They are submitted as a package where they pertain to related items.
 - 5. They are properly marked with service or function identification as related to the project, where they consist of catalog sheets displaying other items which are not applicable.
 - 6. They are properly marked with external connection identification as related to the project where they consist of standard factory assembly or field installation drawings.
- D. Shop drawings submittals processed by the Owner are not Contract Documents and are not Change Orders; the purpose of the shop drawing review is to establish a reporting procedure and is intended for the Contractor's convenience in organizing his work. If deviations, discrepancies or conflicts between shop drawing submittals and the Contract Documents are discovered either prior to or after the shop drawing submittals has been processed by the Owner, the Contractor agrees that the Contract Documents shall control and be followed. Submission of Shop Drawings or commencement of the construction work implies that trade coordination has taken place.

1.07 SAMPLES

- A. In the case of substitutions of specified electrical equipment during the shop drawing phase, the Electrical Contractor, upon request, shall provide the owner with a sample of the substituted equipment for their review.

1.08 SUBSTITUTION OF SPECIFIED EQUIPMENT

- A. In general, substitution of specified electrical equipment will be discouraged. If the Electrical Contractor wishes to substitute specified equipment with units of equal or superior performance characteristics and aesthetic abilities then the Electrical Contractor must first provide the following:

1. Complete shop drawings of said equipment as described and required hereinafter in Section 1.06 "Shop Drawings and Other Information Required".
 2. Indicate a dollar amount that the Electrical Contractor intends to credit back to the owner for utilizing said substituted equipment.
 3. Upon request, furnish samples of substituted equipment as hereinafter required by Section 1.07 "Samples".
- B. Any proposed substitution of equipment must be submitted to the owner no later than fourteen (14) days from the signing of Electrical Section of the Construction Contract. If the Owner has not received the Electrical Contractor's shop drawing submittals for substituted equipment in the steps outlined above within the fourteen day period, then the Electrical Contractor must provide all equipment as specified in the contract documents. The Owner and their Consultants retain the right to reject any and all substituted equipment.

1.09 RECORD DRAWINGS

- A. As part of the required electric work, a complete set of reproducible "as built" or record electrical drawings shall be made up as the job progresses and delivered to the Owner at the conclusion of the work.
- B. The drawings shall show:
1. All electric work installed exactly in accordance with the original design.
 2. All electric work installed as a modification or addition to the original design.
 3. The dimensional information necessary to delineate the exact location of all circuitry and wiring runs (other than lighting an appliance branch circuitry and small control, signal, and communications circuitry runs) which are so buried or concealed as to be untraceable by inspection through the regular means of access established for inspection and maintenance.
 4. The numbering information necessary to correlate all electrical energy consuming items (or outlets for same) to the panel or switchboard circuits from which they are supplied.
- C. The drawings shall be prepared on AutoCAD version 14 or newer and submitted on disk and on one set of reproducible vellums.
- D. The design tracings will be made available for copying into reproducibles should it be determined that such reproducibles would serve as suitable backgrounds for the "as-

built” drawings. The quantity of design tracings which are made available shall in no way be interpreted as setting a limit to the number of drawings necessary to show the required “as built” information.

1.10 INTERPRETATION OF THE DRAWINGS AND SPECIFICATIONS

- A. As used in the drawings and specifications for electrical work, certain non-technical works shall be understood to have specific meanings as follows regardless of indications to the contrary in the general conditions or other documents governing the electrical work.

“Furnish” Purchase and deliver to the project site complete with every necessary appurtenance and support, all as part of the electrical work. Purchasing shall include payment of all sales taxes and other surcharges as may be required to assure that purchased items are free of all liens, claims or encumbrances.

“Install” Unload at the delivery point at the site and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project, all as part of the electrical work.

“Provide” “Furnish” and “Install”.

“New” Manufactured within the past six months and never before used.

- B. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any electrical item in the drawings or specifications for electrical work carries with it the instruction to furnish, install and connect the item as part of the electrical work, regardless of whether or not this instruction is explicitly stated.
- C. It shall be understood that the specifications and drawings for electrical work are complimentary and are to be taken together for a complete interpretation of the electrical work except that indications on the drawings, which refer to an individual element of work, take precedence over the specifications where they conflict with same.
- D. To the extent that they govern the basic work the specifications also govern change order work.
- E. No exclusion from, or limitation in, the symbolism used on the drawings for electrical work or the language used in the specifications for electrical work shall be interpreted

as a reason for omitting the appurtenances or accessories necessary to complete any required system or item of equipment.

- F. The use of words in the singular shall not be considered as limiting where other indications denote that more than one item is referred to.
- G. Ratings of devices, materials and equipment specified without reference to specific performance criteria shall be understood to be nominal or nameplate ratings established by means of industry standard procedures.
- H. The electrical work shall be coordinated with all work required for a complete and operational system.

1.11 EQUIPMENT AND MATERIALS

- A. All equipment and materials for permanent installation shall be the products of recognized manufactures, be UL listed, and shall be new (manufactured within the last six months).
- B. Equipment and materials shall:
 - 1. Where normally subject to Underwriters Laboratory Inc. listing or labeling services, be so listed or labeled.
 - 2. Be without blemish or defect.
 - 3. Not be used for temporary light or power purposes.
 - 4. Be in accordance with the latest applicable NEMA standards.
 - 5. Be products which will meet with the acceptance of all authorities having jurisdiction over the work. Where such acceptance is contingent upon having the products examined, tested and certified by Underwriters or other recognized testing laboratory, the product shall be so examined, tested and certified.
 - 6. Be on the jobsite as required by the construction schedule, and at least four weeks prior to the building opening.
- C. Except for conduit, conduit fittings, outlets boxes, wire and cable, all items of equipment or material of one generic type shall be the product of one manufacturer throughout.
- D. Items which are to be installed but not purchased as part of the electric work shall be carefully examined upon delivery to the project. Claims that any of these items have

been received in such condition that their installation will require procedures beyond the reasonable scope of the electrical work will be considered only if presented in writing within one week of the date of delivery to the project of the items in question. The electric work includes all items for which no claims have been submitted as outlined above.

1.12 TECHNICAL DEFINITIONS

- A. Regardless of their usage in codes or other industry standards, certain words as used in the drawings or specifications for the electrical work, shall be understood to have the specific meanings ascribed to them in the following list:

“Circuitry”	Any electrical work which consists of wires, cables, raceways, and/or specialty wiring method assemblies taken all together complete with associated junction boxes, pull boxes, outlet boxes joints, couplings, splices and connections except where limited to a lesser meaning by specific description.
“Wiring”	Same as Circuitry
“Circuit”	Any specific run of circuitry.
“Branch Circuitry”	Any light and power distribution system circuit which, at it’s load end, is directly connected to none or more electrical energy consuming items with no overcurrent protection devices interposed, other than (where required) those protecting the energy consuming items from overloading or overheating.
“Feeder”	Any item of circuitry used in distribution system which is not branch circuitry.
“Distribution Panel”	Any panel, used in a distribution system, containing only multi-pole branches and with all (or the majority) of its branches used for feeders supplying other panels.
“Power Panel”	Same as distribution panel, except with all (or the majority) of its branches used for feeders which do not supply other panels.
“Building Confines”	The extent of a building, as defined by the outside surfaces of its peripheral walls, the top surface of its roof, and the underside surface of its grade slab.
“Distribution Switch”	Any switch used in a light and power system other than a tumbler, toggle, or specialty switch in the “Wiring device” category.

“Underground”	Subsurface and exterior to building foundations.
“Raceways”	Any pipe, duct, extended enclosure, or conduit (as specified for a particular system) which is used to contain wires, and which is of such nature as to require that the wires be installed by a "pulling-in" procedure.
“Concealed”	(As applied to circuitry)—Covered completely by building materials, except for penetrations (by boxes and fittings) to a level flush with the surface as necessitated by functional or specified accessibility requirements.
“Exposed”	(As applied to circuitry)—Not covered in any way by building materials.
“Primary”	Over 600 Volts.
“Secondary”	Under 600 Volts.
“Assembly”	A defined set of elements of electric work.

- B. Where the word “conduit” is used without specific reference to type, it shall be understood to mean “raceway”.

1.13 MOUNTING HEIGHTS

- A. Mounting heights of all items shall be as directed by the Owner, or as indicated on the Contract Drawings.

1.14 SERVICE CHARACTERISTICS

- A. Secondary Level – 277/480 volts, 3 phase, 4 wire stepped down to 120/208 volts, 3 phase, 4 wire, 60 hertz.
- B. All electrical work shall meet with the approval of the utility company and the local wiring inspector.
- C. All equipment and wiring shall be suitable for the applied voltage.
- D. Perform work on the line side of the point as identified as the service connection in accordance with instructions issued by the utility company.
- E. Provide all appurtenances required for tying into the service connection point in accordance with instructions issued by the utility company.

1.15 INSPECTION OF SITE

- A. Prospective bidders will be permitted to inspect the site prior to the closing of the bidding period so that the bidders may ascertain the scope of work and prevailing conditions. Failure to inspect existing conditions or to fully understand the work which is required shall not excuse the Electrical Contractor from his obligation to provide the work in accordance with the specification and the drawings and under all site conditions as they exist.

1.16 TEMPORARY GENERATOR POWER

- A. Provide adequate electrical capacity from portable generators as required for utility outages and/or removing existing generator(s) from service. The existing non-essential loads shall be provided with at least one source of power throughout the construction period. The existing emergency and standby loads shall be provided with at least two sources of power throughout the construction period

1.17 CUTTING AND PATCHING

- A. Sleeves, inserts, anchor bolts and similar items set into the masonry structure of the work of other trades shall be furnished and installed by the Electrical Contractor. The Electrical Contractor shall be responsible for all such items necessary to hang or support his equipment.
- B. The Electrical Contractor shall do all drilling and cutting of small holes in walls and floors as required for sleeves and supports. The Electrical Contractor shall also be responsible for all floor openings, shafts, etc. larger than 4" in diameter.

1.18 ACCESSIBILITY

- A. All work shall be installed so that parts requiring periodic inspection, operation, maintenance and repair are readily accessible. Minor deviations from the drawings may be made to accomplish this, but changes of substantial magnitude shall not be made prior to written approval from the owner.

PART 2 – PRODUCTS

2.01 WIRING MATERIALS

- A. Utilize wiring methods selected in accordance with the following list.

<u>Wiring Method</u>	<u>Application (subject to restrictions hereinafter)</u>
Galvanized rigid steel conduit with wires pulled in	Exposed service entrance feeders
Schedule 40 Rigid Non Metallic PVC Electrical Conduit With wires pulled in	Feeder and branch circuits buried under floor slabs within the building confines and site lighting and other exterior underground raceways.
½” minimum steel electric metallic tubing with wires pulled in.	Main and branch feeders, branch circuitry and low tension system(s) wiring.
Metal clad cable type MC with Insulated ground conductor	Interior branch circuitry concealed within stud walls and above suspended acoustical tile ceilings <u>only</u> .

- B. Branch circuitry shall not be buried in building floor slabs (except where necessary to feed fixed equipment) – Branch circuitry shall run overhead. Panelboard feeders may be run under floor slabs in approved raceways.
- C. Wires shall be copper with 600V insulation, THWN for branch circuitry and XHHW for feeders. Manufactured cable systems shall be rated for 90o C insulation temperature.
- D. Conductors shall be of soft drawn 98% minimum conductivity properly refined copper, solid construction where No. 10 AWG and smaller, stranded construction where No. 8 AWG and larger.
- E. Exterior of wires shall bear repetitive markings along their entire length indicating conductor size, insulation type and voltage rating.
- F. Exterior of wires shall be color coded, so as to indicate al clear differentiation between each phase and between each phase and neutral. In all cases, grounded neutral wires and cables shall be identified by the colors white or gray. In sizes and

- insulation types where factory applied colors are not available, wires and cables shall be color coded by the application of colored plastic tapes in overlapping turns at all terminal points, and in all boxes in which splices are made. Colored tape shall be applied for a distance of 6 inches along the wires and cables, or along their entire extensions beyond raceways ends, whichever is less.
- G. Final connections to motors shall be made with 18" of neoprene sheathed flexible conduit with insulated grounding associates.
 - H. All exposed area fixture cord or cable drops shall have an outer PVC insulated jacketed assembly factory painted white.
 - I. Minimum conductor size shall be No. 12 AWG.
 - J. Other wires and cables required for the various systems described elsewhere in this section of the Specifications shall be as specified herein, or as recommended by the manufacturer of the specific equipment for which they are used.
 - K. Wiring materials shall be manufactured by Triangle, Republic, Anaconda or General Cable.

2.02 OUTLET, JUNCTION, PULL BOXES, AND WIRING TROUGHS FOR ALL SYSTEMS

- A. The Electrical Contractor shall provide outlet, junction, and pull boxes at all locations where they are required to facilitate the pulling, supporting or connecting of wires and cables. All boxes shall be steel.
- B. Outlet boxes for mounting light fixtures or equipment shall be rated for the weight of the equipment supported.
- C. Outlet and outlet size boxes shall be steel or metal.

2.03 OVERCURRENT PROTECTION AND SWITCHING DEVICES FOR POWER DISTRIBUTION

- A. Select overcurrent protection and switching devices as follows:

<u>Category of Application Types</u>	<u>Acceptable Device (See Legend Below)</u>
Service disconnect unit in main switchboard	SW-BP/CLCF, CB-FAF
Feeder unit in main switchboard	SW-BP/CLCF, or SW- QMQB/CLCF or CB-SMC

	Main and branch units in distribution and power panels (800A and over)	CB-SMC
	Main and branch units in distribution and power panels (under 800A)	CB-SMC
	Branch and main units in lighting and appliance panels	CB-SMC
	Individually mounted devices	SW-QMQB/CLCF or CB-SMC
	Individually mounted unit without overcurrent protection	SW-QMQB
	Fusing from combination motor starter	CLCF
B.	Legend	
	SW-BP	Distribution switch; bolted Pressure type.
	SW-QMQB	Distribution switch; quick-make, quick-break type.
	/	Fusible – fused with.
	CLCF	Current limiting cartridge fuses.
	CB-SMC	Circuit breaker; standard molded case type.
	CB-FAF	Circuit breaker; fixed airframe type.
C.	Devices shall have voltage and interrupting capacity ratings suitable for the supply characteristics to which they are applied.	

2.04 BOLTED PRESSURE TYPE DISTRIBUTION SWITCHES

- A. Bolted pressure type distribution switches shall be as follows:
1. They shall have copper current-carrying elements having silver plated contact surfaces.

2. They shall have blade locks to prevent them from opening under short circuit stresses and a mechanism which produces initial contact pressure on the jaws in addition to final bolted pressure when they are closed.
3. They shall have auxiliary renewable arcing contacts which “make” before and “break” after main current-carrying elements function.
4. They shall be equipped with operating mechanisms which incorporate manual closing and tripping. Where used as service disconnects, they shall incorporate electrical tripping.
5. Where used as main service disconnects they shall be complete with zero sequence ground fault protection systems for use with electric trip. Provide adjustable ground fault current pick up and ground fault time settings with ground fault trip test panel.
6. Where used as main service disconnects they shall have shunt trip devices complete with control transformers, “line side” shunt trip control supply connections and internal factory wiring to accessible terminals as required for the extension of the trip control circuit, at a 120 volt control voltage level, to remote, normally open external actuating devices, such as service ground current tripping and remote shunt trip stations as indicated on the drawings.
7. They shall be designed for use with Class “L” fuses.

2.05 DISTRIBUTION SWITCHES

- A. Quick-make, quick-break, type distribution switches shall equal or exceed the performance required for NEMA type heavy duty (general duty where 60A or less) horsepower rated switches.
 1. They shall have arc quenchers and circuit breaker type pressure contacts
 2. Where of the fusible type, they shall be designed for use with “Class R” fuses up to 600 amps. They shall be equipped with fuse rejection clips to disallow installation of fuses not rated for switch interrupting capacity rating.
- B. Distribution switches shall be as manufactured by Westinghouse, Siemens, Square D, Cutler-Hammer or General Electric.

2.06 PANELBOARDS AND DISTRIBUTION PANELBOARDS

- A. Panelboards shall consist of factory completed deadfront assemblies of back pans, main busses, overcurrent and switching units, sheet metal cabinets and trims. They

- shall be so designed that switching and overcurrent devices can be replaced without disturbing adjacent units and without removing the main bus connectors, so that circuits may be changed without machining, drilling or tapping.
- B. All panelboards shall have a circuit directory card mounted in a frame with plastic cover installed on the inside of the door. All directory cards shall be properly filled in, using a typewriter, and indicating areas and devices served by each circuit.
 - C. Bus bars for their mains shall be of copper having current capacities as indicated and sized for such capacities in accordance with Underwriter Laboratory standards. Unless otherwise noted, full size neutral bars shall be included. Bus bar taps for panels with single pole branches shall be for sequence phasing of the branch circuit devices. Bussing shall be braced throughout to conform to industry standard practice governing short circuit stresses in panelboards. Phase bussing shall be full height without reduction. Neutral bussing shall have suitable lugs for each outgoing feeder requiring a neutral connection.
 - D. A ground bus shall be provided for each panel. Each ground bus shall be of the same material as the phase and neutral buses.
 - E. Their cabinets shall be fabricated from industry standard gauge galvanized sheet steel with corners lapped and riveted, or fastened by approved methods.
 - F. The inside and outside of their trims shall be factory painted with one rustproofing primer coat and one finish coat. The finish paint shall be of a type to which field applied paint will adhere.
 - G. Their cabinets and trims shall be suitable for the required mounting trims shall be screw fastened to cabinets and shall be of a type that is self-supporting on cabinets after screws have been removed. Trims for flush panels shall overlap cabinets by at least ½" all around.
 - H. Cabinets and trims for lighting and appliance panels shall accommodate and conform to the following limiting dimensions:
 - 1. Minimum wiring gutter width on each side – 5-3/4"
 - 2. Maximum overall width – 24"
 - 3. Maximum overall depth – 6"
 - I. Where wires or cables are used within panelboards to make-up internal connections (factory installed or otherwise) such wire or cable shall have copper conductors only.
 - J. Any cabinet for power or distribution panel shall (regardless of the actual devices required to be in it) have a width and a depth adequate for a three pole branch device equal to 50% of the rating of the panel mains.

- K. Where indicated or as required to assure ready accessibility of top switching and overcurrent device, they shall be arranged as multiple adjacent sections. A single overall cabinet shall be supplied for the multiple adjacent sections which constitute one panel. ¼" minimum thickness plastic barriers having adequate angle iron framing such as to include wiring gutter space for each section as if it were an individual panelboard. Common bussing shall be arranged for adjacent sections unless there is indication that the individual sections are to be separately supplied. Sub-feed lugs with full capacity cables taps to adjacent panel sections will be accepted as the bussing method.
- L. Hinged doors covering all switching device handles shall be included in all panel trims.
- M. Doors in panelboard trim shall conform to the following:
 - 1. In making switching device handles accessible, doors shall not uncover any live parts.
 - 2. Doors shall have flush type paracentric cylinder locks and catches, except that doors over 48" in height shall have a vault handle and a 3-point catch, complete with lock, arranged to fasten door at top, bottom and center. Two keys shall be supplied for each lock and each key shall open all panelboards. Locks and keys shall conform to a "standard keying policy" as directed.
- N. Where "spaces only" for overcurrent protection and switching devices are called for in a panel, its main bus, and backpan, as well as its cabinet and trim, shall be extended to accommodate these spaces.
- O. Panelboards shall comply with the following industry standards.
 - 1. UL Standards
 - a. Panelboards – UL 67
 - b. Cabinet & Boxes – UL 50
- P. Provide "lock on" clips for the toggle handles of branch circuit breakers serving the Fire Alarm System and Telephone System. Provide panelboard nameplates as per Section 3.08
- Q. Flush mounted panels shall be provided with 1-1" empty conduit terminating in a pull box above the ceiling. If ceiling is constructed of drywall; providing and access panel.
- R. Panelboards shall be located on full height walls.

- S. Panelboards shall be as manufactured by General Electric, Siemens, Westinghouse or Square D.

2.07 WIRING DEVICES

- A. Provide wiring device type plates for all wall mounted devices. All wiring devices shall be white in color. Verify with Owner before ordering.
- B. Wiring device switches shall be toggle type AC quiet design, specification grade, with trim rings, 20 amps on 120V or 277V circuits. Switches shall be mounted 48" to centerline A.F.F. unless noted otherwise switches shall be installed with "off" position down.
- C. Standard duplex convenience receptacles shall be 125 volt, 20 amps, three wire (two circuit wire plus grounds), "U-bar" ground NEMA slot configuration 5-20R, specifications grade. Receptacle heights shall be 18" to centerline A.F.F. unless noted otherwise.
- D. Receptacles designated as ground fault circuit interrupters shall be feed through type.
- E. Where more than one wiring device is indicated in the same location, the devices shall be mounted in gangs under a common wallplate.
- F. Wallplates to be white. Verify with Owner before ordering.
- G. The height of all devices shall be verified with the Owner.
- H. Wiring devices shall be as manufactured by Leviton, Bryant or Hubbell.

2.08 LIGHTING FIXTURES

- A. Lighting fixtures shall be as hereinafter specified.
- B. Finishes shall be as selected by the Architect or as indicated in the light fixture schedule.
- C. Any additional appurtenances required for installation and operation, where same are not covered by the identification used on the drawings, shall be included. Include the aiming and/or adjustment of all lighting fixtures, requiring same, in accordance with instruction issued by the field architect.
- D. Any additional appurtenances required for installation and operation, where same are not covered by the identification used on the drawings, shall be included. Include the

aiming and/or adjustment of all lighting fixtures, requiring same, in accordance with instruction issued by the field architect.

- E. Recessed fixtures throughout shall have their components, wiring and external connections coordinated for use in ceilings utilized as air handling plenums.
- F. Fixtures for use outdoors or in areas designated as damp locations, shall be suitably gasketed.
- G. All ballasts or transformers for discharge type lamps shall be for 60 cycles operation.
- H. All ballasts or transformers for discharge or fluorescent type lamps shall be high power factor, full light output, electronic type. Provide individual fusing for ballasts where required by local wiring inspector.
- I. Ballasts for fluorescent lamps shall be industry standard protected type "P".
- J. All ballasts or transformers for discharge type lamps intended for use outdoors shall be of the low temperature type having the lowest temperature rating available in standard manufacture.
- K. All ballasts or transformers shall be of the low energy full light output type where available. Each shall not exceed industry minimum rated input wattage by more than 8%.
- L. The contractor shall obtain all information relative to the exact type of hung ceilings and suspension systems to be installed before ordering any recessed fixtures. This Contractor shall furnish the proper type fixtures applicable to the ceiling framing system. If, other than the type of fixtures specified are required for installation due to the type of ceiling construction, the Contractor shall furnish and install the proper type fixtures and mounting appurtenances required at no extra charge to the Owner or others.
- M. The Contractor shall coordinate the exact locations of all lighting fixtures with the ceiling pattern during the Construction Period and before installation of the fixtures. Interferences between lighting fixtures, and other equipment, shall be brought to the attention of the Construction Manager.

2.09 MOTOR CONTROLS

- A. Equipment in Mechanical Systems.
 - 1. In conjunction with the equipment which occurs in mechanical systems, included in the electric work will be:

- a) The furnishing and installing of motor starters where required.
- b) The furnishing and installing of motor power circuitry up to motor terminals with connection to same.
- c) The furnishing and installing of required line disconnect means.
- d) The line fusing of all fusible combination starters.
- e) The furnishing and installing of HVAC and refrigeration control.

B. Motor Starters

- 1. The starter for each motor shall be suitable for the motors, and shall be equipped with all features and appurtenances required for proper operation.
- 2. Each motor starter shall be equipped with a NEMA Class I enclosure installed indoors unless otherwise noted.
- 3. Each motor starter installed outdoors, or in areas within the building confines designated as damp or wet locations shall be equipped with a NEMA Class 3R weatherproof enclosure.
- 4. Each phase magnetic or manual starter shall be equipped with an operating pole in each phase.
- 5. Magnetic starters of the combination type shall be equipped with a disconnect pole in each phase.
- 6. Manual starters of the combination type shall be equipped with a disconnect pole in each phase.
- 7. Magnetic starters of the combination fusible switch type where indicated shall have fuse gaps sized for time delay type fusing (RK-5).
- 8. Each motor starter shall be equipped with manual reset running overcurrent relay for each pole rated not in excess of the nameplate current of the associated motor.
- 9. Each magnetic starter shall have the holding coil and any other required control relay coils suitable for line-to-line operation-where starter is NEMA size 1 or larger; it shall be equipped with line voltage to low voltage control transformers tapped off the power circuit line. Control voltage shall be 120V AC or 25V DC as required by Mechanical Contractor.

10. Each magnetic starter NEMA Size 2 and larger, shall be equipped with an auxiliary control circuit relay arranged to permit the actuation of the strter without introducing holding coil currents into the external control circuit.
11. Covers of combination starters shall be suitably hinged and interlocked with the handle of the disconnect means to prevent opening when the handle is in closed.
12. Each combination type motor shall be equipped with approved padlock and key and a means for padlocking its manual line disconnect in the open position.
13. Each motor starter shall be equipped with an engraved lamacoid nameplate permanently screw fastened on the outside of the starters cover -- the nameplate shall show ¼" high white lettering on a black background identifying the motor controlled.
14. The electrical contractor shall provide for each magnetic starter all auxiliary contacts required for interlocking or control purposes.
15. Motor starters for motor rated 3 Hp and over system shall be provided on "ON" time relays arranged to energize the holding coils after an adjustable range of 0.05 to 180 seconds.
16. Motor starters for motors rated 25 Hp and over shall be reduced voltage type.
17. Motor starters which are not part of packaged equipment shall be by one manufacturer throughout the project.
18. Motor starters shall be as manufactured by Cutler-Hammer, Westinghouse, Square D, General Electric, or other approved.

C. Motor Control Actuating Devices

1. All manual motor control actuating devices indicated as being required in starter covers shall be delivered so mounted to the project.
2. All motor control actuating devices indicated as not being in the starter covers shall be delivered to the site housed in NEMA Class I General Purpose Enclosures, except that where intended for use in exterior locations, they shall be housed in NEMA 3R Enclosures-where two or more motor control actuating devices are to be installed separately from a motor starter, but at a single location, such devices shall be delivered to the site ganged together in a single enclosure.

3. All motor control actuating devices shall have contacts rated at least 10 amperes at 250 volts regardless of the actual duty they are required to perform.
4. Pushbuttons shall be of the normal duty spring return momentary type.
5. Selector switches shall be of the normal duty maintained contact type.
6. Pilot lights shall be neon tube type with candelabra base and clear glass.
7. Pushbuttons shall be equipped with nameplates indicating their functions as noted in the list of electric motors and motor controls.
8. Selector switches shall be equipped with nameplates indicating the function as noted in the list of their positions as noted in the list of electric motors and motor controls.
9. Pilot lights shall be equipped with nameplates indicating the operating condition they annunciate as noted in the list of electric motors and motor controls.
10. Devices such as pushbuttons, pilot lights and selector switches, where mounted in enclosures other than the cover of the starter, shall be equipped with nameplates indicating the motor with which they are associated.
11. "Hand-Off-Remote" type selector switches in starter covers shall be of the key operated cylinder lock type, arranged for locking in the "remote" position with the key removable in this position only- All switches shall be keyed alike.

D. Motor Control Circuitry

1. Except as noted below, select materials exactly as specified for feeders. Utilize No. 12 A.W.G. THWN conductors throughout; except in conjunction with a manual starter utilize conductors equal in size to those in the power circuit.
2. Motor control circuit wires may be run in the same conduit as the wires of motor power circuits; however, exclude motor control wires from enclosures (other than motor starter enclosures) which contain power circuit overcurrent protection and switching devices; also from pull boxes and junction boxes containing the wires of main the submain feeders. Utilizes auxiliary pull boxes to separate motor control wires from motor power circuit wires before the power circuit wires enter the items from which motor control wires are excluded.

2.10 GROUNDING REQUIREMENTS

- A. Ground all systems and equipment in accordance with best industry practice, ANSI/NFPA 70 and current industry standards.
- B. The ground bus of the main switchboard shall be connected to the main grounding electrode specified below by means of insulated conductors run in conduit.
- C. The main grounding electrode shall be an accessible point on the nearest metallic main water service pipe. Connection shall be made on the street side of the main valve utilizing a ground clamp of a type specifically manufactured for the purpose. Bonding jumpers shall be provided around the water meters (if provided) and around insulating joints and/or sections.
- D. Establish a ground bonding connection from the effectively grounded structural building steel to each cold water main entering the building. Each bonding connection shall consist of insulated conductors run in conduit.
- E. The metallic water pipe shall be supplemented by an additional "made" electrode consisting of buried $\frac{3}{4}$ " diameter by 10'-0" long copperweld ground rods spaced 6'-0" minimum apart, and provided in sufficient quantity so as to have measured resistance to ground of not more than 25 ohms. Establish a bonding connection from the "made" electrode consisting of green insulated conductors run in conduit and sized as indicated hereinafter for main "supply side of service" bonding jumpers.
- F. Provide grounding bonds between all metallic conduits of the light and power system which enter and leave cable chambers or other non-metallic cable pulling and splicing boxes. Accomplish this by equipping the conduits with bushings of the grounding type individually cross connected.
- G. Bond metallic conduits containing grounding electrode conductors and main bonding conductors to the ground bus service enclosure and/or grounding electrode at both ends of each run utilizing grounding bushings and jumpers.
- H. Provide grounding bonds for all metallic conduits of the light and power system which terminate in pits below equipment for which a ground bus is specified. Accomplish this by equipping the conduits with bushings of the grounding type connected individually to the ground bus.
- I. Provide supplementary ground bondings where metallic conduits terminate at metal clad equipment (or at the metal pull box equipment) for which ground bus is specified. Accomplish this by equipping the conduits with bushings of the grounding type connected individually by means of jumpers to the ground bus. Exclude the jumpers where directed. This exclusion will be required where an isolated ground for electronic equipment is to be maintained.

- J. Each grounding type bushing shall have the maximum ground wire accommodation available in standard manufacture for the particular conduit size. Connection to bushing shall be with of this maximum size.
- K. Bonding conductors on the load size of the service device and equipment grounding conductors shall be sized in relation to the fuses or trip size for the overcurrent device supplying the circuit.
- L. Connections of ground wires shall be in accordance with the following:

LOCATION	GROUND WIRE CONNECTION
Junction box at which non-metallic Conduits terminate	Metal body of junction Box
Main switchboard or isolated Ground panel	Switchboard ground bus
Equipment grounding conductor In branch circuits and feeders	Panelboard, distribution panelboard or Switchboard bus from which branch circuit or feeder originates.

- M. A properly sized equipment grounding conductor shall be run with all circuits installed in PVC, EMT or rigid steel raceways.

2.11 CARTRIDGE FUSES

- A. Cartridge fuses shall be as follows:
1. Regardless of actual fault current, they shall, at full recovery voltage, be capable of safely interrupting fault currents of 200,000 amperes RMS symmetrical or 340,000 amperes RMS asymmetrical, deliverable at the line side of the fuses.
 2. They shall be of the dual element, current limiting, time delay type, having average melting time characteristics to meet Underwriters Laboratories requirements for "Class RK-5" fuses where 600 amperes or less, Class "L" for 601 amperes and greater.
 3. They shall be suitable for application to fuse gaps which reject other types of fusing.

4. Supply 10 percent spare fuses of each size and type 60 amps and less. Supply three spare fuses for each size and type over 60 amps.
- B. Cartridge fuses shall be manufactured by Buss or Shawmut.

2.12 MOLDED CASE CIRCUIT BREAKERS

- A. Molded case type circuit breakers shall consist of manually operated quick-make quick-break mechanically trip free operating mechanisms for simultaneous operation of all poles, with contacts, arc interrupters and trip elements for each pole, all enclosed in molded phenolic plastic cases.
1. Their tripping units shall be of the “thermal magnetic” type having bimetallic elements for time delay overload protections and magnetic elements for short circuit protection.
 2. They shall be manually operable by means of toggle type operating handles having “tripped” position midway between the “on-off” position.
 3. They shall each be contained in an individual case enclosing only the number of poles required for the particular breaker.
 4. Their interrupting rating shall not be less than as indicated in the panelboard schedules on the drawings.
 5. They shall be of the “bolted-in” type.
 6. Where necessary, to accommodate other requirements, their frame sizes shall be increased to conform to such requirements.
 7. They shall have non-interchangeable trips.
 8. Where single pole in trip sizes 20 amps or less, they shall be rated for switching duty.
 9. They shall be equipped with 5 milliamp sensitivity ground fault interrupting features where so indicated.

2.13 DRY TYPE TRANSFORMERS

- A. Provide individually mounted dry type transformers in accordance with the following:
1. They shall be of the indoor ventilated type, drip proof construction.

2. They shall be 3 phase step down, 60 cycles operation.
 3. They shall be equipped with lifting eyes.
 4. They shall each have a delta connected high side rated for 480 volts and wye connected low side rated for 120/208 volts, unless noted otherwise.
 5. They shall have full capacity taps below normal in their high side windings as follows:

Transformer rating	Taps
Less than 45 KVA	Two 5%
45 KVA and above	Four 2-1/2%
 6. They shall have sheet metal casings which are coated inside and out with a rust inhibiting primer and finished with a factory coat of enamel.
 7. The center tap or neutral of the load side transformer windings shall be bonded to a lug and to a bolt inside the transformer casing. The bolt shall extend outside to serve as a system grounding stud. The bond to the bolt shall be an ampere capacity of no less than 20% of the capacity of a load side phase winding.
 8. Transformer insulation should be rated at 80 degrees C Rise.
 9. They shall be floor mounted on rubber isolation pads.
- B. Dry type transformers shall be manufactured by Siemens-Allis, Westinghouse, Sorgel or General Electric.
- C. Provide transformer nameplates as per Section 3.08.

2.15 SERVICE GROUND

- A. A ground fault protection system shall be provided at the switchboard main overcurrent device. It shall consist of a current sensor, relaying device and test/monitor panel. Components shall be designed to operate in conjunction with each other, and the system shall be UL Listed. Installation of the equipment shall in all respects be in accordance with the manufacturer's recommendations.
- B. Each current sensor shall be of sufficient size to properly encircle all phase and neutral conductors of the circuit to be monitored. The current sensor output shall be coordinated with the input required by the ground fault relay. Each current sensor shall include a test winding which allows the complete system, including the current sensor, ground fault relay, and circuit interrupting device, to be tested under

- simulated ground fault conditions. The frame of each current sensor shall be constructed so that one leg can be removed to prevent disturbing cables or bussing during installation or removal of the system.
- C. Each ground fault relay output shall be coordinated to operate an interposing relay which shall be designed to be used in conjunction with 120 volt control power. This combination shall operate the electrical tripping mechanism of an associated overcurrent and switching device specified herein.
 - D. Current settings for the ground pickup point shall be field adjustable continuously from 200 through 1200 amperes. A calibrated dial shall be provided for setting the ground fault pickup point. The time delay of the ground fault relays shall be factory set as per National Electrical Code requirements.
 - E. A factory assembled test/monitor panel shall be supplied which uses the test winding of the current sensor to simulate a ground fault condition. This test system shall be UL Listed to comply with the National Electrical Code requirements for performance testing. System operation as a result of a ground fault shall be confirmed by lighting a red indicating lamp.

2.17 EMERGENCY LIGHTING SYSTEMS

- A. Each system shall include a self-contained emergency lighting unit with fixtures and lamps, internal battery, battery charger, pilot light monitors, primary protection fuses, and relay or switching device arranged to connect the lighting load to the battery upon failure of AC power. Remote head emergency fixtures, lamps and external wiring shall comprise the remainder of each system. Each system shall operate on 12 volts DC and shall be connected to an unswitched 120 or 277 volt AC power supply.
- B. Each system shall be so designed that in the event of a power failure, the emergency units shall instantaneously turn on all DC emergency lighting system shall provide a minimum of 90 minutes of light. Simultaneous with resumption of normal electric service following a power failure, the emergency fixtures shall be extinguished and the batteries shall be recharging automatically at fast-charge rate. AT the conclusion of the automatic fast-charge period, the batteries shall be fully and completely recharged, and a trickle charge shall be reestablished to maintain a constantly full battery charge.
- C. The self-contained emergency lighting units shall contain all required control circuitry to give complete electrical supervision of the battery and automatic charger circuits. The charging transformers shall be of the high impedance type. A voltmeter and ammeter shall be part of each unit and shall have an accuracy of not less than 2%. The units shall be equipped with signal lights that indicate the following:

Primary AC supply on

Trickle charge to battery on
Fast charge to battery on
Trouble in operation circuits
Trouble in supervisory circuits

- D. Batteries shall be sealed lead acid type nominally rated for 12 volts and shall have sufficient capacity to carry the connected load for not less than 90 minutes to not less than 87-1/2% of nominal system voltage.
- E. Remote fixtures and lamps shall be the size, type and wattage as required. The Electrical Contractor shall provide all hardware necessary for proper installation.
- F. Each emergency lighting unit shall be guaranteed against defects in material and workmanship for a period of five (5) years, pro rata.

2.20 ELECTRONIC BALLASTS

- A. Fluorescent lamp ballasts shall be electronic type of use with either straight or "U" lamps.
- B. The ballast manufacturer shall have been producing electronic ballasts in the United States for at least five (5) years.
- C. Electronic ballasts shall be interchangeable as to size, mounting and voltage characteristics of core an coil type ballasts.
- D. Electronic ballasts shall be UL listed, comply with all State and Federal Energy Code standards and be utility "eligible" where required.
- E. Ballasts shall comply with FCC and NEMA limits governing electromagnetic and radio frequency interface (RFI) and shall not interfere or disrupt other building electrical equipment.
- F. Ballasts shall comply with all ANSI and IEEE Standards regarding surge protection and harmonic distortion. Total harmonic distortion level of ballasts shall be less than 20% THD, but greater than 10% THD.
- G. Ballast lamp crest factors shall be less than 1.6 and power factor shall be a power factor greater than 90%.
- H. Ballasts shall not be affected by lamp failure and shall not have a detrimental effect on lamp life. Parallel circuit ballasts shall allow remaining lamp(s) to maintain full output and one lamp has failed.
- I. Ballast sound rating shall be "A" or better and shall contain no PCB's.

- J. Ballasts shall operate at an input frequency of 60 hertz and an input voltage of 108 to 132 volts for 120V models and 249 to 305 volts for 277 volt models.
- K. Ballasts shall be potted and enclosed in a steel case.
- L. Ballast operating temperature shall not exceed 60° at any point on the case during normal operation.
- M. Ballasts shall be solid state, high frequency type.
- N. Ballasts shall have a 3 year warranty with a minimum of \$10.00 labor replacement allowance.
- O. Ballast shall be as manufactured by Magnetek, Triad, Osram or approved equal.

2.21 EMERGENCY POWER DISTRIBUTION SYSTEM

- A. The emergency/standby electric generating set shall be automatic starting, diesel fuel driven; and shall have nominal electric characteristics as indicated on the drawings and shall be able to supply its indicated KW load at power factors down to 80%.
 - 1. These ratings shall be with water pump and fan radiator attached and shall be verified by the manufacturer. The unit shall be capable of picking up its rated capacity in one step and provide a transition time, from instant failure of the normal power source to the standby generator source, of 10 seconds or less.
 - 2. The generator set shall be EPA Certified and UL 2200 Certified including all current requirements.
- B. Engine and generator shall be a "factory package" mounted in a weather protective housing on a rigid base consisting of a full length skid or rail of structural steel on each side and cross bracing members at each end. The steel skid base shall be provided with lifting points. Provide unit mounted spring type linear vibration isolators at base. Housing shall include an acoustical baffled sound attenuated enclosure and the base shall be provided with a 48 hour fuel tank.
- C. The diesel engine shall be water cooled, 6 cylinder, 4-cycle, industrial type as required by unit rating.
- D. The engine shall be a diesel fired engine which shall operate satisfactorily on a commercial grade #2 diesel fuel supply.

- E. The complete diesel engine generator unit shall be free from critical and torsional vibration within the operating speed range. The engine is to be furnished complete with the following accessories:
1. Full pressure lubrication system with full flow and bypass type lubricating oil filters.
 2. Heavy duty replaceable element dry type air cleaner for air intake system.
 3. An iso-electronic governor to maintain speed at precise isochronous control for rated frequency operation. The frequency at any constant load, including no load, shall remain within a steady state band width of plus or minus 0.25% of rated frequency.
 4. Overspeed shutdown control for protection against overspeeding. Overspeed control shall be solid state type.
 5. A unit mounted fan and radiator cooling system. The system shall be designated to satisfactorily cool the unit in an ambient temperature of 120 degrees F (50 degrees C). Fan shall be of the air foil direct drive design and electric motor type.
 6. A 24-volt heavy duty electric starter, alternator, and voltage regulator shall be provided.
 7. Engine jacket water heater and lube oil heater complete with thermostatic controls mounted, piped and wired on the engine.
 8. The generator set shall be furnished with all required safety controls and pre-alarms to interface with the generator control panel.
 9. The diesel fuel system shall include, but not be limited to; cast iron fuel line strainer, carburetor, dual element fuel filter, and a flexible steel fuel line connector.
 10. A coolant drain line with valve.
- F. Generator output voltage shall be 277/480 volts, 3-phase, 4 wire, 60 Hertz. Generator shall be of brushless construction.
1. The voltage regulation shall be plus or minus 1% from no-load to full-load and 5% frequency variation. Regulator drift shall be less than 1% per 72 degrees F (40 degrees C) ambient temperature change.

2. Voltage dip shall not exceed 30% upon application of full continuous rated load, at 0.8 PF, with recovery to steady state band conditions within one second as measured on a light beam recorder. The generator shall be brushless permanent magnet oversized by 25% of unit rating.
 3. The wave from harmonic distortion shall not exceed 5% total RMS measured line-to-line at full rate load.
 4. Generator shall have IP23 protection rating.
 5. Class H insulation with Class H temperature rise.
- G. All performance and temperature rise data submitted by the generator manufacturer shall be the result of the actual test of the same or duplicated generators. Temperature rise data shall be the result of full load, 0.8% PF heat runs at the rated voltage and Hertz. All performance testing shall be done in accordance with MIL-STD-705 and /or IEEE Standard 115.
- H. Engine generator set control system shall consist of a unit mounted digital control panel containing engine and generator instruments. Engine instruments shall include battery charging ammeter, water temperature gauge, lube oil pressure gauge, lube oil temperature gauge and hour meter. Generator instruments shall include AC Ammeter, AC voltmeter with output voltage adjustment, power factor indicator, KW and KVAR indicators, run hours, fault history and frequency meter (pointer type). Provide auxiliary contacts for operation of remote signals and air intake louvers. A combination ammeter/voltmeter phase-to-phase selector switch shall be included. The control system shall provide automatic starting upon closing of a remote contact in the transfer switches. The automatic start control shall include LED indication of panel functions and sequence of operation. Control shall provide cycle cranking and rest periods and three position function selector switch (auto/off/test). The following visual alarm and safety shutdown monitoring shall be provided:
1. Selector in "Auto" – green light.
 2. Overcrank – red light and shutdown.
 3. Overspeed – red light and shutdown.
 4. Low oil pressure – red light and shutdown.
 5. High water temperature – red light and shutdown.
 6. Low water temperature – orange light (alarm only).
 7. Approach low oil pressure – orange light (alarm only).

8. Approach high water temperature – orange light (alarm only).
 9. Alarm silenced – orange light.
 10. Battery charger malfunction.
 11. Low fuel level.
 12. Low coolant level.
 13. “Not in auto” position – orange light (alarm only)
 14. RS485 port, modem interface, software and terminal strip and necessary wiring shall be included for remote annunciation to be located at the Critical Operations Center room 129 and Communications room 162.
- I. A critical silencer muffler and catalytic converter shall be provided as part of the factory package. The silencer shall be mounted so that its weight is not supported by the engine and so that exhaust system growth due to thermal expansion will not be imposed on the engine. Provide exhaust piping up the side of the building to above the roof line similar to the existing exhaust piping system. Exhaust piping system shall be sized as required for the engine requirements and piping length including all bends and pressure restrictions.
- J. The starting system shall be included with a 24 volt, 30 ampere battery charging alternator with voltage regulator, automotive type starting motor, starting solenoid, and auto start control.
- K. A 24-volt heavy duty storage battery shall be provided, mounted on battery rack, having sufficient capacity and be complete with necessary cables and connectors.
- L. Automatic current limiting float battery chargers shall be provided for maintaining the batteries at full charge at all times. They shall be fed from a 120 volt, single phase, 60 Hertz service and the D.C. output shall be wired to the batteries. Economy type trickle charger obtained from an auto supply house will not be acceptable.
- M. Main line 100% trip rated, molded case circuit breakers as indicated on the drawings shall be mounted upon the generator as load circuit interrupting and protection devices. They shall operate both manually for normal switching functions and automatically during overload and short circuit conditions. Circuit breakers shall have battery voltage operated shunt trip wired to safety shutdowns to open breakers in the event of engine failure.

- N. Control panel and trickle charger and all connections between same and the generating set shall be included in the factory package.
- O. Provide an air intake system as required to adequately ventilate the generator enclosure during unit operation. The generator enclosure shall be constructed of heavy gauge steel, factory painted green, with lockable hinged doors on three sides of the housing. Provide a full catwalk around the generator housing including stairs for full access to all electrical and mechanical equipment.
- P. A double wall 48 hour fuel tank shall be mounted within the skid base of the unit. The tank shall incorporate threaded pump connections, 120 volt AC suction pump, float switch, fuel gauge, check valve, high fuel level and low fuel level alarm contacts and flexible fuel connections to the engine. Tank fuel connections and alarms shall meet all New Hampshire rules and regulations.
- Q. The complete diesel generator set shall be factory tested at its full load prime and standby rating. This test shall be conducted at 0.8% PF and shall demonstrate governor transient response for pickup of full load in one step and rejection of full load in one step. Certified copies of the factory test shall be furnished to the Owner.
- R. After installation, an installation test shall be performed under the supervision of a factory-trained service technician, provided by the manufacturer of the engine generator set. The field test shall include simulating a power failure including operation of the transfer switch, and, a full load test for four hours utilizing a portable test bank. During the load test the following electrical measurements shall be recorded hourly:
1. Kilowatts
 2. Amperes
 3. Voltage
 4. Coolant temperature
 5. Enclosure temperature
 6. Frequency
 7. Oil temperature
 8. Battery, output voltage
- The unit shall be warranted for five years or 1500 hours of operation, whichever occurs first. Provide full maintenance contract for 5 years.
- S. Before field testing, provide all fuels and/or liquids necessary for operation of the generating set. The Electrical Contractor shall be responsible for providing 300 gallons of diesel fuel.

- T. Shop drawing submittal shall include catalog cuts, wiring diagrams, interface drawings, AC & DC schematics, terminal strip drawings, and annunciator panel layout and wiring information.
- U. Provide two remote annunciator and alarm panels which will duplicate the audible and visual signals located on the generator control panel. Locate the remote annunciators in the Critical Operations Center and Communications Room.
- V. Generating sets shall be as manufactured by Caterpillar, Cummins, Kohler or approved equal.

2.22 AUTOMATIC TRANSFER SWITCHES

- A. The automatic transfer switch shall consist of a power transfer module and a control module, interconnected to provide complete automatic operation with the following characteristics:
 - 1. It shall be mechanically held and electronically operated by a single-solenoid mechanism energized from the source to which the load is to be transferred.
 - 2. It shall be rated for continuous duty and be inherently double throw.
 - 3. It shall be mechanically interlocked to ensure only one of two possible positions -- normal or emergency.
 - 4. It shall be suitable for use with emergency sources such as an engine or turbine driven generator source or another utility source.
 - 5. The operating transfer time in either direction shall not exceed one-sixth (1/6) of a second.
 - 6. It shall always seek the normal (or preferred) source when available.
 - 7. All components shall be front accessible and front removable.
- B. Inspection of all contacts (movable and stationary) shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to stop the contacts at any point throughout the entire travel to properly inspect and service the contacts when required.
- C. Automatic transfer switches shall conform to the requirements of NEMA Standard ICS 2-447 and Underwriters' Laboratories UL 1008 and shall be UL listed as follows:

1. For use in emergency and standby systems in accordance with Article 700 of the National Electrical Code.
 2. Rated in amperes for total system transfer including control of motors, electric-discharge lamps, electric-heating and tungsten-filament lamp loads.
 3. Rated to withstand the RMS symmetrical short circuit current available at the automatic transfer switch terminals with the type of overcurrent protection and voltage as shown in the plans.
- D. Automatic transfer switches shall be mounted in NEMA Type 3R Pad mounted non-walk-in enclosures. Enclosures shall meet the requirements of NEMA Standard ICS6 and UL Standard Number 508. Enclosure shall be equipped with a factory installed 120V heater and thermostat.
- E. All phases of the normal shall be monitored line-to-line. Close differential voltage sensing shall be provided on all phases. The pickup voltage shall be adjustable from 85% to 100% of nominal and the dropout voltage shall be adjustable from 75% to 98% of the pickup value. The transfer to emergency will be initiated upon reduction of normal source to 85% of nominal voltage and retransfer to normal shall occur when normal source restores to 90% nominal.
- F. Provide in phase monitor controls for transfer and retransfer of motor loads, so that inrush currents do not exceed normal starting currents, to avoid nuisance tripping of circuit breakers and possible mechanical damage to motor couplings.
- G. Provide independent single phase voltage and frequency sensing of the emergency source. The pickup voltage shall be adjustable from 90% to 100% of nominal. Transfer to emergency upon normal source failure when emergency source voltage is 90% or more of nominal and frequency is 95% or more of nominal.
- H. Provide a green signal light to indicate when the automatic transfer switch is connected to the normal source. A red signal light to indicate when the automatic transfer switch is connected to the emergency source.
- I. Provide one auxiliary contact that is closed when automatic transfer switch is connected to normal and one auxiliary contact that is closed when automatic transfer switch is connected to emergency.
- J. Provide test switch to momentarily simulate normal source failure, initiate engine starting and transfer to emergency source.
- K. Where indicated as 3 phase, 4 wire transfer switches: Provide insulated neutral bus with bonding/grounding point and connections for normal, emergency and load conductors.

- L. Provide exerciser option with two position selector switch (load/no load) and electronic time clock to automatically exercise the generator set at pre-arranged periods. Provide two position selector switch (load/no load) for periodic exercising of the unit under load.
- M. Provide control circuit from the generator control panel to the automatic transfer switches for auto start.
- N. Automatic transfer switches shall be as manufactured by Automatic Switch Company, Caterpillar, Kohler or approved equal.

2.23 SHORT CIRCUIT / COORDINATION STUDY AND ARC FLASH HAZARD ANALYSIS

- A. The Short Circuit Studies, Protective Device Evaluation Studies, and Protective Device Coordination Studies as well as the Arc Flash Analysis shall be performed by the Electrical Contractor utilizing a professional electrical engineer or selected electrical distribution equipment manufacturer. The studies shall be submitted to the Engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to the release of equipment for manufacture. If formal completion of the studies may cause delay in equipment manufacture, approval may be obtained for a preliminary submittal of sufficient study data to ensure that the selection of device ratings and characteristics will be satisfactory.
- B. The Electrical Contractor utilizing a professional electrical engineer or selected electrical distribution equipment manufacturer shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in the current issue of NFPA 70E – *Standard for Electrical Safety in the Workplace*. The Arc Flash Hazard Analysis shall be performed according to the IEEE Standard 1584-2002, the *IEEE Guide for Performing Arc-Flash Calculations*.
- C. The studies shall include all portions of the electrical distribution system from the normal power source(s) and any emergency or standby power sources down to and including all the 480V and 208V distribution systems.
- D. The Short Circuit/Coordination Study shall be in accordance with the following standards:
 - 1. IEEE 141 – Recommended Practice for Electrical Power Distribution and Coordination of Industrial and Commercial Power Systems
 - 2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
 - 3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis

4. IEEE 241.0 Recommended Practice for Electrical Power Systems in Commercial Buildings
 5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
 6. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations
 7. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
 8. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
 9. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 10. ANSI C37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
 11. NFPA 70 – National Electrical Code, latest edition adopted in state of jurisdiction.
 12. NFPA 70E – Standard for Electrical Safety in the Workplace
- E. The study input data shall include the power company's short circuit contribution, resistance and reactance components of the branch impedances, the X/R ratios, base quantities selected, and other source impedances.
- F. Short circuit momentary duty values and interrupting duty values shall be calculated on the basis of assumed three-phase bolted short circuits at each switchgear bus, switchboard, motor control center, distribution panelboard, pertinent branch circuit panel and other significant locations throughout the system. The short circuit tabulations shall include symmetrical fault currents and X/R ratios. For each fault location, the total duty on the bus, as well as the individual contribution from each connected branch, shall be listed with its respective X/R ratio.
- G. A protective device evaluation study shall be performed to determine the adequacy of overcurrent and switching devices and automatic transfer switches, by tabulating and comparing the short circuit ratings of these devices with the calculated fault currents. Appropriate multiplying factors based on system X/R ratios and protective device rating standards shall be applied. Any problem areas or inadequacies in the equipment due to short circuit currents shall be promptly brought to the Engineer's attention.
- H. A protective device coordination study shall be performed to provide the necessary calculations and logic decisions required to select or to check the selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low voltage breaker trip characteristics and settings. The objective of the study is to obtain optimum protective and coordination performance from these devices.
- I. The coordination study shall include all low voltage classes of equipment from the utility's incoming line protective device down to and including the lowest rated

device in the 208 volt distribution equipment. The phase and ground overcurrent protection shall be included as well as settings of all other adjustable protective devices.

- J. The time current characteristics of the specified protective devices shall be graphed. The graphs shall include complete titles, representative one-line diagram and legends, associated power company's relays or fuse characteristics, significant motor starting characteristics, complete parameters of transformer withstand limits and significant symmetrical and asymmetrical fault currents. All restrictions of the National Electrical Code shall be adhered to and proper coordination intervals and separation of characteristic curves shall be maintained. The coordination plots for phase and ground protective devices shall be provided on a system basis. A sufficient number of separate curves shall be used to clearly indicate the coordination achieved.
- K. The selection and settings of the protective devices shall be provided separately in a tabulated form listing circuit identification, IEEE device number, current transformer ratios and recommended power fuse selection shall be provided for the medium voltage fuses where applied in the system. Any discrepancies, problem areas, or inadequacies shall be promptly brought to the Engineer's attention.
- L. The results of the power system study shall be summarized in a final report. Five (5) bound copies of the final report shall be submitted to the Engineer. Electronic PDF copies of the report shall be provided on request.
- M. The report shall include the following selections:
 - 1. Executive Summary including Introduction, Scope of Work and Results/Recommendations.
 - 2. Short-Circuit Methodology Analysis Results and Recommendations.
 - 3. Short-Circuit Device Evaluation Table.
 - 4. Protective Device Coordination Methodology Analysis Results and Recommendations.
 - 5. Protective Device Settings Table.
 - 6. Time-Current Coordination Graphs and Recommendations.
 - 7. Arc Flash Hazard Methodology Analysis Results and Recommendations Including the details of the incident energy and flash protection boundary calculations, along with Arc Flash boundary distances, working distances, Incident Energy levels and Personal Protection Equipment levels.
 - 8. Arc Flash Labeling section showing types of labels to be provided. Section will contain descriptive information as well as typical label images.
 - 9. One-line system diagram that shall be computer generated and will clearly identify individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location, device numbers used in the time-current coordination analysis, and other information pertinent to the computer analysis.

- N. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the responsible charge and approval of a Registered Professional Electrical Engineer or Electrical Distribution Equipment Manufacturer skilled in performing and interpreting the power system studies.
- O. The studies shall be performed using SKM Systems Analysis* Tools for Windows (PTW) software program or other approved program.
- P. The equipment manufacturer shall provide the services of a qualified field engineer and necessary tools and equipment to test, calibrate, and adjust the protective relays and circuit breaker trip devices as recommended in the power system study.
- Q. The Arc Flash Hazard Analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E, Annex D. The Arc Flash Hazard Analysis shall be performed in conjunction with the short-circuit analysis and the protective device time-current coordination analysis.
- R. The flash protection boundary and the incident energy shall be calculated at significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway etc.) where work could be performed on energized parts.
- S. Circuits 208V or less where available bolted short circuit current is less than 10kA may be omitted from the computer model and will be assumed to have a hazard risk category 0 per NFPA 70E Table 130.7(C)(9)(a), including footnote 3.
- T. Circuits 208V or less fed by transformers 112.5 KVA or less may be omitted from the computer model and will be assumed to have a hazard risk category 0 per IEEE 1584.
- U. Working distances shall be based on IEEE 1584. The calculated arc flash protection boundary shall be determined using those working distances.
- V. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.
- W. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location in a single table. Calculations must be performed to represent maximum and minimum contributions of fault current magnitude for normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum. Conversely, the maximum calculation will assume a maximum contribution from the utility. Calculations shall

take into consideration the parallel operation of synchronous generators with the electric utility, where applicable as well as any stand-by generator applications.

- X. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors should be decremented as follows:
 - 1. Fault contribution from induction motors should not be considered beyond 5 cycles.
- Y. For each piece of ANSI rated equipment with an enclosed main device, two calculations shall be made. A calculation shall be made for the main cubicle, sides, or rear; and shall be based on a device location upstream of the equipment to clear the arcing fault. A second calculation shall be made for the front cubicles and shall be based on the equipment's main device to clear the arcing fault. For all other non-ANSI rated equipment, only one calculation shall be required and it shall be based on a device location upstream of the equipment to clear the arcing fault.
- Z. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.
- AA. Mis-coordination should be checked amongst all devices with the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.
- BB. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. A maximum clearing time of 2 seconds will be used based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.
- CC. Provide the following:
 - 1. Results of the Arc-Flash Hazard Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, working distances, personal-protective equipment classes and AFIE (Arc Flash Incident Energy) levels.
 - 2. The Arc-Flash Hazard Analysis shall report incident energy values based on recommended device settings for equipment within the scope of the study.
 - 3. The Arc-Flash Hazard Analysis may include recommendations to reduce AFIE levels and enhance worker safety.

- DD. The Electrical Contractor shall provide a 4.0 in. x 4.0 in. thermal transfer type label of high adhesion polyester for each work location analyzed.
- EE. The labels shall be designed according to the following standards:
1. UL969 – Standard for marking and labeling systems
 2. ANSI-Z535.4 – Product Safety Signs and Labels
 3. NFPA 70 (National Electric Code) – Article 110.16
- FF. The label shall include the following information:
1. System Voltage
 2. Flash protection boundary
 3. Personal Protective Equipment category
 4. Arc Flash Incident energy value
 5. Limited, restricted, and prohibited approach boundaries
 6. Study report number and issue date
- GG. Labels shall be printed by a thermal transfer type printer, with no field markings and shall be suitable for the environment that they are installed in.
- HH. Arc flash labels shall be provided for equipment as identified in the study and the respective equipment access areas per the following:
1. Floor Standing Equipment – Labels shall be provided on the front of each individual section. Equipment requiring rear and/or side access shall have labels provided on each individual section access area. Equipment line-ups containing sections with multiple incident energy and flash protection boundaries shall be labeled as identified in the Arc Flash Analysis table.
 2. Wall Mounted Equipment – Labels shall be provided on the front cover or a nearby adjacent surface, depending upon equipment configuration.
 3. General Use Safety labels shall be installed on equipment in coordination with the Arc Flash labels. The General Use Safety labels shall warn of general electrical hazards associated with shock, arc flash, and explosions, and instruct workers to turn off power prior to work.

PART 3 - EXECUTION

3.01 BASIC REQUIREMENTS

- A. Adhere to best industry practice and the following.
- B. All work shall be concealed except exposed where run horizontally at ceiling of unfinished spaces, or through mechanical and electrical equipment spaces.
- C. Equip each raceway intended for the future installation of wire with nylon cord.
- D. Provide all outlet boxes, junction boxes, and pull boxes for proper wire pulling and device installation. Include those omitted from the drawings due to symbolic methods of notation.
- E. Equip each raceway intended for the future installation of wire with a nylon cord.
- F. Provide all outlet boxes, junction boxes, and pull boxes for proper wire pulling and device installation. Include those omitted from the drawings due to symbolic methods of notation.
- G. Provide all sleeves through fireproof and waterproof slabs, walls, etc., required for electric work.
 - 1. Provide waterproof sealing for the sleeves through waterproof slabs, walls, etc.
 - 2. Provide fireproof sealing for the sleeves through fireproof walls, slabs, etc.

3.02 TESTS

- A. Before an application for final acceptance of the work will be considered, all tests deemed necessary by the Owner to show proper execution of the work shall have been performed and completed in the presence of the Owners representative. Scheduling of all testing procedures shall be arranged to suit the convenience of the Owner.
- B. Any defects or deficiencies discovered in any of the electrical work shall be corrected and promptly retested. Defective materials shall be replaced at no cost to the Owner.
- C. After the electrical work is completed and tested, deliver three copies of the manufacturer's operation manuals, shop drawings, wiring diagrams, and parts list for each device by other requirements specified elsewhere.

- D. On the day the facility is turned over to the Owner, the electrical contractor shall insure that a licensed electrician is present at the building for at least eight hours to insure that all electrical systems are operating properly.

3.03 BRANCH CIRCUITRY

- A. For all lighting and appliance branch circuitry, raceway sizes shall conform to industry standard maximum permissible occupancy requirements except where these are exceeded by other requirements specified elsewhere.
- B. For circuitry indicated as being protected 20 amps or less, abide by the following:
1. Except as specified below, minimum conductor size shall be No. 12 AWG copper.
 2. Conductors for 115 volts to neutral circuitry extending in excess of 100 feet, from the point of supply, to the last outlet or fixture tap shall be a minimum of No. 10 AWG copper throughout.
 3. Conductors for 277V circuitry extending in excess of 200 feet, from the point of supply to the last outlet or fixture tap, shall be a minimum of No. 10 AWG copper throughout.
- C. Lighting fixtures and receptacles shall not be connected to the same circuit.
- D. Circuitry for emergency and exit sign lighting fixtures shall be maintained separate from all other circuitry.
- E. Circuits shall be balanced on phases at their supply point as evenly as possible.

3.04 REQUIREMENTS GOVERNING ELECTRIC WORK IN DAMP OR WET LOCATIONS

- A. Exclude flexible metallic conduit except for final connections not in excess of six feet.
- B. Outlets and outlet size boxes shall be of galvanized cast ferrous metal.
- C. The finish of threaded steel conduit shall be galvanized.
- D. Wire for pulling into raceways for lighting and appliance branch circuitry shall be limited to "THWN".
- E. Wires for pulling into raceways for feeders shall be limited to "THWN".
- F. Wiring device plates shall be galvanized sheet steel.

- G. Plates for toggle switches and receptacles shall have gasketed snap shut covers.
- H. Final connections of flexible conduit shall be neoprene sheathed.
- I. Enclosures, junction boxes, pull boxes, cabinets, cabinet trims, wiring troughs and the like, shall be fabricated of galvanized sheet metal and shall conform to the following:
 - 1. They shall be constructed with continuously welded joints and seams.
 - 2. Their edges and weld spots shall be factory treated with cold galvanizing compound.
 - 3. Their connection to circuitry shall be by means of watertight hub connectors with sealing rings.
- J. Enclosures for individually mounted switching and overcurrent devices shall be NEMA Class 3R weatherproof construction.
- K. The covers, doors and plates and trims used in conjunction with all enclosures, pull boxes, outlet boxes, junction boxes, cabinets and the like shall be equipped with gaskets.
- L. Panels shall be equipped with doors without exception.
- M. The following shall be interpreted as damp or wet locations within the building confines:
 - 1. Spaces where any designations indicating weatherproof (WP) or vaporproof appear of the drawings.
 - 2. Below waterproofing in slabs apply directly on grade.
 - 3. Sprinkler rooms.
 - 4. Other designated areas.

3.05 ELECTRIC MOTOR DRIVE EQUIPMENT

- A. For electric driven mechanical system equipment, include:
 - 1. Power circuitry with connections to motor.
 - 2. Individually mounted line disconnect means.

3. Installation of motor starters.
4. Line fusing of motor starters.
5. If necessary, the substitution of local multiple disconnect means with suitable overcurrent protection for the indicated single unfused device when necessary to meet the actual power supply requirements of package motorized equipment which is shown supplied by a single feed but which is not adapted to same.

3.06 IDENTIFICATION AND TAGGING

- A. Identify individually:
 1. Each panelboard.
 2. Each disconnect switch.
 3. Each dry type transformer.
- B. Each wire or cable in a feeder shall be identified at its terminal points of connection and in each pullbox, junction box and panel gutter through which it passes.
- C. The nomenclature used to identify panelboards shall designate the numbers assigned to them.
- D. The nomenclature used to identify switches or circuit breakers shall:
 1. Where they disconnect mains or services designate this fact.
 2. Where they control feeders, designate the feeder number and the name of the load supplied.
 3. Where they control lighting and appliance branch circuitry, designate the name of the space and the load supplied.
- E. The nomenclature used to identify feeder wires and cables shall designate the feeder number.
- F. Identification for panelboards and transformers shall be by means of engraved lamacoid nameplates showing 1/4" high white lettering on a black background screen fastened to the outside face of the front.
- G. Identification for switches or circuit breakers shall be by means of the following:

1. Where individually enclosed – engraved lamaroid nameplates showing 1/8" high white lettering on a black background fastened on the outside front face of the enclosure.
 2. Where in panelboards without doors– same as for individually enclosed.
 3. Where in panelboards with doors – typewritten directories mounted behind transparent plastic covers, in metal frames fastened on the inside face of the doors.
- H. Identification for the wires and cables of feeders shall be by means of wrap around “Brady” type labels.
- I. Device plates for local toggle switches, toggle switch motor starters, pilot lights and the like, whose function is not readily apparent shall be engraved with 1/8" high letters suitably describing the equipment controlled or indicated.
- J. Phase identification letters shall be stamped into the metal of the bus bars of each phase of the main buses of each switchboard and each panelboard. The letters shall be visible from at least one “normal posture” location without having to remount any current carrying or supporting elements.
- K. Equip the front face of all switchboards pull boxes junction boxes and the like containing cables, busing or devices operating in excess of 600 volts with enameled sheet metal “red on white” signs reading “DANGER – HIGH VOLTAGE”.
- L. Equip all electric closets and the like with enameled sheet metal “red on white” signs reading “Electrical Equipment Room – No Storage Permitted”. Signs shall be mounted at clearly visible locations within the rooms.
- M. Provide a sign at the service entrance equipment room indicating the type and location of all on site emergency or standby power sources.
- N. Identify each outlet box, junction box, and cabinet used in conjunction with empty raceway for wires of a future system by means of indelible markings on the inside denoting the system.
- O. Prior to installing identifying tags and nameplates, submit their nomenclature for approval.

3.07 SUPPORTS AND FASTENINGS

- A. Support work in accordance with best industry practice.

- B. No work intended for exposed installation in damp locations shall be mounted directly on any building surface. In such locations, flat bar members or spacers shall be used to create a minimum of 1/4" air space between the building surfaces and the work.
- C. Nothing (including outlet, pull and junction boxes and fittings) shall depend on electric conduits, mechanical piping of equipment, raceways or cables for support.
- D. Nothing shall rest on, or depend for support on, suspended ceiling media. Vertical members which suspend the ceiling, however, may be used for support.
- E. Fasten electric work to building structure in accordance with the best industry practice.
- F. Floor mounted equipment shall not be held in place solely by its own dead weight. Include floor anchor fastenings in all cases.
- G. Fasten electric work to building structure in accordance with the best industry practice.
- H. Floor mounted equipment shall not be held in place solely by its own dead weight. Include floor anchor fastenings in all cases.
- I. For items which are shown as being ceiling mounted at locations where fastenings to the building construction element above is not possible, provide suitable auxiliary channels or angle iron bridging tying to building structural elements.
- J. Provide expansion fittings wherever building expansion joints occur or wherever raceways run through isolated slabs.

3.08 REQUIREMENTS FOR THE INSTALLATION OF JUNCTION BOXES, OUTLET BOXES, AND PULL BOXES

- A. Flush wall mounted outlet boxes shall not be set back to back but shall be offset at least 12" horizontally regardless of any indication on the drawings.
- B. Locate all boxes so that their removable covers are accessible without necessitating the removal of parts of permanent building structure, including piping, ductwork, and other permanent mechanical elements.
- C. Barriers in junction and pull boxes of outlet size shall be of the same metal as the box.
- D. Apply junction and pull boxes in accordance with the following:
 - 1. Include pull boxes in long straight runs of raceway to assure that cables are not damaged when they are pulled in.

2. Include junction and pull boxes to assure a neat and workmanlike installation of raceways.
3. Include junction and pull boxes to fulfill requirements pertaining to the limitations to the number of bends permitted in raceway between cable access points, the accessibility of cable joints and splices, and the application of cable supports.
4. Include all required junction and pull boxes regardless of indications of the drawings (which, due to symbolic methods of notation, may omit to show some of them).

3.09 LOCATING AND ROUTING OR CIRCUITRY

- A. All circuitry shall be run concealed except that it shall be run exposed where the following conditions occur:
 1. Horizontally at the ceiling of permanently unfinished spaces which are not assigned to mechanical or electrical equipment.
 2. Horizontally and vertically in mechanical equipment spaces.
 3. Horizontally and vertically in electric equipment rooms.
- B. Concealed circuitry shall be so located that building construction materials can be applied over its thickest elements without being subject to spalling or cracking.
- C. Circuitry run exposed shall be routed parallel or perpendicular to building walls and column lines.
- D. Exposed circuitry located overhead shall be run in a completely accessible manner on the under side of all piping and ductwork.
- E. Circuitry run in suspended ceilings shall be routed parallel or perpendicular to building walls, column lines, etc.
- F. All circuitry shall be run concealed except that it shall be run exposed where the following conditions occur:
 1. Horizontally at the ceiling of permanently unfinished spaces which are not assigned to mechanical or electrical equipment.
 2. Horizontally and vertically in mechanical equipment spaces.

3. Horizontally and vertically in electric equipment rooms.

3.10 INSTALLING CIRCUITRY AND RACEWAYS

- A. In runs of conduit or raceway including flexible limit the number of bends between cable access points to a total which does not exceed the maximum specified for the particular system. Where no such maximum specified, limit the number to four right angle bends or the equivalent thereof.
- B. In each conduit or raceway assigned for the future pulling in of wires, include a nylon drag cord.
- C. In each conduit or raceway assigned for the future pulling in or wires, include a nylon drag cord. In raceways 2" trade size and larger, the cord shall be pulled in utilizing a suitable brush, followed by an 85% diameter ball mandrel ahead of the cord in the pulling assembly. In the event that obstructions are encountered, which will not permit the drag cord to be installed, the blocked section of raceway shall be replaced and any cutting and patching of the structure involved in such replacement shall be included as part of the electric work.
- D. Circuitry shall be arranged such that conductors of one feeder or circuitry carrying "going" current are not separated from conductors of the same feeder or circuitry carrying "return" current by any ferrous or other metal. Where not within raceways, all "going" and "return" current conductors of one feeder or circuit shall be laced together so as to minimize induction heating of adjacent metal components.
- E. Sleeves use where circuitry is to penetrate waterproof slabs, decks and walls, shall be of a type selected to suite the water condition encountered in the field.
- F. Provide suitable raceway fittings to accommodate expansion and deflection where conduit(s) cross seismic, control and/or expansion joints.
- G. Ground and bond all conduit under provisions of Section 2.16.
- H. Route conduits through roof openings for piping and ductwork or through suitable roof jack with pitch pocket. Coordinate with mechanical and roofing contractors.

3.11 PHASING AND COLOR CODING

- A. The insulation or covering of each wire or cable shall be color coded so as to provide for circuit identification as specified below.

<u>120/208V Circuits</u>	<u>Phase</u>	<u>277/480V Circuits</u>
Black	A	Brown

Red	B	Orange
Blue	C	Yellow
White	Neutral	White
Green	Ground	Green

- B. The same colored cable shall be connected to the same phase throughout the project.
- C. In general, building load centers and panelboards shall be phase "A", "B", "C", either top to bottom or left to right. The neutral, although it may be in different locations for different equipment, shall be identified.

3.12 REQUIREMENTS GOVERNING ELECTRIC WORK IN RETURN AIR PLENUMS

- A. In spaces within suspended ceilings utilized as return air plenums, abide by the requirements specified for normal electric work conditions except:
 - 1. Lighting fixtures recessed into the ceiling shall be certified for being suitable for this purpose.
 - 2. All wiring systems must either be run in metallic raceways or shall be UL approved fire rated plenum cable.

3.13 SPARE PARTS, SPECIAL TOOLS

- A. The following spare parts shall be provided to the Owner at no additional cost to the base contract price:
 - 1. Additional copy of each type panelboard circuit directory (see 2.06 PANELBOARDS).
 - 2. Additional set of each set of keys utilized for electrical equipment on the project (fire alarm control panel, panelboards, etc.).
 - 3. Three (3) spare fuses of each type of fuse utilized on the project.
- B. Special Tools: If any part of equipment furnished under these specifications requires a special tool for assembly, adjustment, setting or maintenance thereof and such tool is not readily available on the commercial tool market, shall be furnished with equipment as a standard accessory.

3.15 MECHANICAL AND ELECTRICAL COORDINATION

- A. The Mechanical and Electrical Subcontractors shall coordinate their respective portions of the work, as well as the electrical characteristics and voltage requirements of all electrically operated mechanical equipment.

- B. The Electrical Contractor shall review all mechanical, architectural, structural, and civil drawings and specifications associated with this project, prior to submitting his/her bid, to ascertain the total scope of work for this project. Submission of an electrical bid on this project confirms that the Electrical Contractor has reviewed all related contract documents and understands the scope of work for this project.

3.16 REQUIREMENTS GOVERNING ELECTRIC WORK IN AIR HANDLING SPACES

- A. Within air handling duct work or plenums (other than spaces within suspended ceilings used for air handling purposes).
 - 1. Abide by the requirements specified for electric work in damp locations within building confines.
 - 2. Where circuitry passes through duct walls, include, in accordance with instructions issued in the field, air-tight sealing provisions which allow for a relative movement between the circuitry and the duct walls.
- B. In spaces within suspended ceilings used for air handling purposes, abide by the requirements specified for normal electric work conditions except:
 - 1. Lighting fixtures recessed into the ceilings shall be certified as being suitable for this purpose.

3.17 UNDERGROUND CONDUIT BANKS

- A. Conduits for underground banks shall be:
 - 1. Trade diameter size as indicated but in no case less than one inch.
- B. Lay conduit to avoid low points during run. Pitch at a minimum of three inches per 100 feet away from building.
- C. Provide reinforcement for the concrete encasement of a conduit bank where:
 - 1. It passes under or over other underground utilities.
 - 2. It passes under or over underground obstructions.
 - 3. Its cover is reduced to less than 30 inches.
 - 4. It runs through foundation walls and other building construction.

- D. Install conduit so that adjacent joints are staggered at least six inches from one another.
- E. Offsets to accommodate field conditions shall be accomplished with two bends of not more than ten degrees each.
- F. Plug both ends of all conduits stubs.
- G. Seal the end of each conduit run terminating inside a building utilizing a water and gas-tight sealant manufactured specially for the purpose.
- H. After conduit has been installed with concrete encasement completed, clear each conduit of all obstructions and foreign matter by pulling a flexible mandrel (12" minimum length and a diameter 1/4" less than that of the conduit) and brush through it. In the event that obstructions are encountered in any conduit which will not permit the mandrel to pass, remove and replace the blocked section. Include in the electric work all excavation, backfilling, repair of concrete encasement and restoration of surface at grade involved in the conduit replacement.
- I. Provide a nylon cord for pulling of cable in each conduit in which no cable is to be installed as part of the electric work.

3.18 LIMITING NOISE PRODUCED BY ELECTRICAL INSTALLATION

- A. Perform the following work, in accordance with field instructions issued by the Owner to assure that minimal noise is produced by electrical installations due to equipment furnished as part of the electrical work.
- B. Check and tighten the fastenings of sheet metal plates, covers, doors and trims used in the enclosures of electrical equipment.
- C. Remove and replace any individual device containing one or more magnetic flux path metallic cores (e.g. discharge lamp ballast, transformer, reactor, dimmer, solenoid) which is found to have a noise output exceeding that of other identical devices installed at the project.

3.19 SPLICING AND TERMINATING WIRES AND CABLES

- A. Maintain all splices and joints in removable cover boxes or cabinets where they may be easily inspected.
- B. Locate each completed conductor splice or joint in the outlet box, junction box, or pull box containing it, so that it is accessible from the removal cover side of the box.

- C. Join solid conductors No. 8 AWG and smaller by securely twisting together and soldering or by using insulated coiled steel spring "wire nut" connectors. Exclude "wire nuts" employing non-expandable springs. Terminate conductors No. 8 AWG and smaller by means of a neat and fast holding application of the conductors directly to the binding screws or terminals of the equipment or devices to be connected.
- D. Join, tap terminate stranded conductors No. 6 AWG or larger by means of solder sleeves, taps; and lugs with applied solder or by means of bolted saddle type or pressure indent type connectors, taps, and lugs. Exclude connectors and lugs of the types which apply set screws directly to conductors. Where equipment or devices are equipped with set screw type terminals which are impossible to change, replace the factory supplied set screws with a type having a ball bearing tip. Apply pressure indent type connectors, taps and lugs utilizing tools manufactured specially for the purpose and having features preventing their release until the full pressure has been exerted on the lug or connector.
- E. Except where wire nuts are used, build up insulation over conductor joints to a value, equal both in thickness and dielectric strength, to that of the factory applied conductor layers of rubber tape, with an outer layer of friction tape; by means of half-lapped layers of approved plastic electric insulating tape; or by means of split insulating casings manufactured specifically to insulate the particular connector and conductor, and fastened with stainless steel or non-metallic snaps or clips.
- F. Exclude splicing procedures for neutral conductors in lighting and appliance branch circuitry which utilize device terminals as the splicing points.
- G. Exclude joints or terminations utilizing solder in any conductors used for grounding or bonding purposes.
- H. Exclude all but solder or pressure indent type joints in conductors used for signaling or communications purposes.

3.20 PULLING WIRES INTO CONDUITS AND RACEWAYS

- A. Delay pulling in until the project has progressed to a point when general construction procedures are not liable to injure wires and cables, and when moisture is excluded from raceways.
- B. Utilize nylon stakes or metallic fish tapes with ball type heads to set up for pulling. In raceways 2" trade size and larger, utilize a pulling assembly ahead of wires consisting of a suitable brush followed by an 3-1/2" diameter ball mandrel.
- C. Leave sufficient slack on all runs of wire and cable to permit the secure connection of devices and equipment.

- D. Include circular wedge-type cable supports for wires and cables at the top of any vertical raceway longer than 20 feet. Also include additional supports spaced at intervals which are no greater than 10'. Supports shall be located in accessible pull boxes. Supports shall be of a nondeteriorating insulation material manufactured specifically for the purpose.
- E. Pulling lubricants shall be used. They shall be products manufactured specifically for the purpose.
- F. Slack on wires and cables located in cabinets and pull boxes shall be formed and set in place in groupings corresponding to their occupancy of raceways. They shall also be arranged, with insulators and supports provided where necessary, such that cable shims or other such temporary expedients do not have to be left permanently in place to prevent the wires and cables from shifting when covers or trims are removed.

END OF SECTION
(214216 8/3/2015)